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THE COMING WHEAT SCARCITY.

The Wheat Problem. Based on remarks made in the Presidential Address to the British Association at Bristol in 1898. Revised, with an answer to various critics. By Sir William Crookes, F.R.S. (London: John Murray, 1899.)

THIS essay by Sir William Crookes, as will be remembered, called forth much criticism when it was delivered as the Presidential Address at the Bristol meeting of the British Association. Now that it is reprinted with additions, it may demand a more careful review than was possible at the time. The general idea, it may be said, is by no means novel, and it is one which approved itself to common sense. The population of the world and of different races in the world increases at rates which are more or less ascertainable. The means of supplying its wants, either in the shape of coal, or metals, or food, is also limited, either by the amount of the accumulated stocks, or the means of working them, or the extent of the earth's surface available for producing the food. What more natural then than to calculate, as has been done by Malthus, as to food generally, by other statisticians as to food in particular districts, such as India at the present time, by Jevons as to coal in England, by Prof. Cairnes as to metals generally, and by Prof. Suess, an Austrian geologist and statistician, as to gold specially, that at a given date in future the supply must run short, and then a crisis arrive? Sir William Crookes applies specially to the study of wheat production this leading idea. The consumers of wheat, he tells us, are a little over 500 millions at the present time, having increased to that figure from about 370 millions in 1870, while the quantity of the earth's surface available for wheat is itself limited both by the capacity of the soil and the necessity for cultivating other products. He calculates accordingly that by the year 1931, if population increases as it has done, the supply of wheat will be seriously short, and he suggests that chemistry should come to the rescue by devising means to fix the nitrogen of the atmosphere so as to permit the growth of more wheat on the same soil.

In all this argument, except as to the last suggestion, Sir William Crookes is plainly on the common ground of men of science and philosophers. He may be right or wrong as to details, such, for instance, as fixing 1931 for the time when the "shortage" of wheat will be felt; but given the initial hypotheses, there must be in time a deficiency of the supply to meet the demand for wheat—as well as for other food articles, it may be added—if present conditions of growth of population, and growth of wealth per head in that population, continue.

But at this point I fear the main commendation of Sir William Crookes' essay must stop. His attempt to give precision to the prospect as regards wheat (and the whole gist of his paper is to emphasise the precision of the forecast) appears to me rather to fail, while he does not handle statistical data in the skilled, scientific manner we should expect from a man of his eminence even in a field which he does not usually cultivate. Above all, instead of confining himself to the forecast that a certain position will be arrived at at a future date, if present conditions continue, the conclusion to which expert statisticians now confine themselves, he assumes the continuance of the conditions, and argues for practical measures to meet the apprehended difficulty. In other words, although the general idea of the essay is sound, the execution appears to be somewhat wanting, and the result is not altogether what we should expect from a man of science so distinguished as Sir William Crookes.

To take first the last point mentioned, the failure to recognise the necessary limitation of all such speculations in consequence of the assumption that must be made that present conditions continue unaltered. I hold this to be a capital error on the part of Sir William Crookes. There has been much experience of these discussions since the time of Malthus, and the whole effect of the experience is that, as yet, we are either too far away from the limits when shortness of supply of food and raw materials, which men of science and philosophers anticipate, will be felt, to engage in a precise discussion, or that we know too little as to the ultimate causes of existing conditions to be able to predict whether they will be soon changed or not. The forecasts of Malthus regarding England and the older countries of Europe that the supply of food would run short have not yet come true, because an outlet in the shape of emigration to new countries has been provided, with the double effect that the multitudes who were expected by Malthus to live in the old countries and press on the narrow supplies there are now largely settled in new countries, and are not only growing food for themselves, but for some of the multitudes remaining in the old countries as well, this last condition being rendered possible by the entirely new developments of means of communication which have taken place since Malthus wrote. Since Malthus wrote, also, there has been a general and vast improvement in the art of cultivating the soil. Similarly, as regards coal, the growth of the demand has by no means continued at the rate which Jevons found in existence when he wrote, while the influence of the price of coal as a factor in production has diminished in consequence of the greater effectiveness of the machinery which coal is used to drive. The scarcity of the supply of gold, which the Austrian geologist anticipated, seems also to be deferred indefinitely by the discoveries in the Transvaal, Western Australia, and the Klondyke; while as to the demand for gold, it is equally plain that nothing is more uncertain than the continuance of the present condition of an overwhelming desire by military governments to secure and lock up enormous sums of gold. Experience is thus altogether against making precise forecasts on the lines laid down by Malthus. Consequently, when a new authority takes up a similar subject, we should expect him to be wide-awake to such considerations, as have been found so important in like cases. The conclusions should always be stated with an "if"—a big "if"—and there should be no attempt at precision in the forecasts, against which there are so many chances that they will not, in fact, be realised. The man of science should be content with pointing out that if his previsions are not realised then existing conditions must change, and the future inquirer should be vigilant in observing the changes. Sir William Crookes has not done this, but has assumed that present conditions will continue, and that his prophecy must come true almost to the letter, which places the discussion altogether on a wrong basis.

The handling of the statistical data also, as I have said, is not what one should have expected from Sir William Crookes. To begin with, the relative place of wheat as an article of food supply to the Caucasian race appears to be very much exaggerated. Sir William Crookes, though he does not say so explicitly, really speaks of wheat as the principal food.

> "My chief subject," he says, "is of interest to the whole world—to every race—to every human being. It is of urgent importance to-day, and it is a life and death question for generations to come. I mean the question of food supply. Many of my statements you may think are of the alarmist order. Certainly they are depressing; but they are founded on stubborn facts. They show that England and all civilised nations stand in deadly peril of not having enough to eat. As mouths multiply food resources dwindle. Land is a limited quantity, and the land that will grow wheat is absolutely dependent on difficult and capricious natural phenomena."

And more to the same effect. The identification of "wheat" in particular with "food" in general without any discussion of the relative importance of wheat among food articles, in the economy of the peoples concerned, is thus complete. The fact is, however, that wheat is only a fractional part of the food of some of the peoples who consume wheat, especially of the European peoples and the people of the United States, who are by far the largest consumers, and that it could be dispensed with and replaced by other articles wholly or in great part if necessity should arise. Take the case of the United Kingdom alone. Our imports of wheat and wheat-flour last year amounted to rather less than thirty-eight millions sterling, and if we allow for home production we may place our national expenditure on wheat at about fifty millions annually at the outside. Our total annual expenditure on food must be about eight times that sum. Our expenditure on imported food alone—meat, cereals, sugar, rice, &c.—was last year over 170 millions sterling, and if we add to that the home production of meat, dairy produce and cereals, we very soon get to a total figure of 400 millions or thereabouts. Sir William Crookes is thus anxious about an article of food on which we depend only to the extent of one-eighth. It may be rejoined that wheat is specially important on physiological grounds, but if so, these grounds should have been stated, and there is certainly no statement in the paper. The money test, the test of actual expenditure, is in any case not an unfair one. It would be the same, we believe, if Sir William Crookes were going farther afield. The people of the United States are very like ourselves as regards food consumption, and, to some extent, the peoples of France and Germany; while among others, whose diet is different from ours, wheat is still relatively unimportant, because, though they do not consume meat as the peoples of this country and the United States do, yet articles like rye and potatoes really constitute their main food, wheat being almost an article of luxury by comparison, and not a principal food. Nowhere, according to Sir William Crookes' own showing, is so much wheat consumed per head as in France, the United Kingdom, and the United States, the very countries in which its relative importance is lowest as an article of diet. It may be suggested, then, that in a scientific inquiry as to the possible shortage of food supplies in the near future the various chief articles of food of the peoples concerned, such as meat, dairy produce, fish, potatoes and sugar, should have been considered, and not merely wheat. There is another reason for this course. Suppose, as I believe to be the case, that a large part of the earth's surface is now used for the production of expensive articles of food like meat and dairy produce with the minimum of cultivation, the most that could happen as supplies became short might be a change of cultivation, involving some addition, but perhaps no great addition, to the cost of production, but resulting in a simultaneous increase of the quantities of meat, dairy produce and cereals produced. The play, then, between different articles of food must be considered. If one article like wheat is taken by itself, it is plainly only a question of price. At a point, the soil now used in growing meat and dairy produce by means of permanent pasturage could easily be taken to produce wheat or other cereals without any diminution, but rather along with an increase, of the production of meat and dairy produce at the same time, though at perhaps rather more cost. At what point will shortage of all supplies, taken together, be felt, and how? are the questions for the man of science and agriculturist, and they are not to be answered by the sort of rule of thumb which is here applied to wheat.

There is yet another serious oversight, in my judgment, when we look at the paper from a purely statistical point of view. Sir William Crookes goes into great detail as to the acreage under wheat in different countries at different periods, but regarding the other side of the comparison, the population of bread-eaters and their rate of growth, he gives no details at all. He confines himself to the following assertion:

> "In 1871 the bread-eaters of the world numbered 371,000,000. In 1881 the numbers rose to 416,000,000; in 1891 to 472,600,000; and at the present time they number 516,500,000. The augmentation of the world's bread-eating population in a geometrical ratio is evidenced by the fact that the yearly aggregates grow progressively larger. In the early seventies they rose 4,300,000 per annum, while in the eighties they increased by more than 6,000,000 per annum, necessitating annual additions to the bread supply nearly one-half greater than sufficed twenty-five years ago."

Clearly a statement like this ought not to be made in a scientific paper, where a great deal turns upon the statement, without the details and references enabling any one to verify and appreciate it. Of course, it is quite possible for any one knowing population statistics, and content to classify large populations as bread-eating, without inquiring in detail what proportion in each population is really bread-eating, to make up a statement for himself; but there are cases of difficulty in any such grouping, and we are entitled to know what Sir William Crookes has done. In a scientific question like this he should have been more specific for another reason. As the consumption of wheat per head in different wheat-eating populations varies a good deal, much may turn upon the nature of the increase, whether it is largest among the communities consuming wheat largely, or among the communities who consume little. To comprehend, in fact, the real growth of wheat-consuming power, we must have an average which allows for the different rates of consumption among the wheat-eating peoples, with references to the authorities for the statements as to each people. To set out this was of the essence of the problem Sir William Crookes had before him, and he has omitted it altogether. The nature of the increased consumption in each country should also have been investigated. It is asserted among farmers, for instance, that a considerable quantity of wheat, more than used to be the case, has of late years been taken in England for other purposes than the food of man, the wheat being given to cattle. Every one knows, again, that flour itself in domestic economy is more and more being applied as an element in cooking articles of luxury, and that it is not really used to a large extent as a principal food at all. All this adds to the interest of the problem as to any approaching shortage of wheat, and the means of making it good, because so much may at need be diverted back from other purposes to the primary use as food; and it shows also that the question of wheat consumption is not one that can be studied, for any such purpose as that contemplated by Sir William Crookes, without an infinity of detail. In any case, it was a matter of scientific good faith that he should have given the details and the references for the important statement we have quoted, which he has not done.

I am not making a mere formal objection. It is, of course, difficult to criticise without having before us the details which Sir William Crookes has not given, but I have not the smallest doubt that the largest increase of bread-eaters, which his details would show, is among the peoples consuming little per head, and not mainly among the peoples consuming much. One of the countries where wheat consumption per head is largest is France, and France is stationary in population.

Having made these general observations on the method followed in the essay, I do not feel called upon to go into detail respecting the actual acreage, and possible acreage, of wheat, in different countries, on which Sir William Crookes has so much to say. There is no question really more difficult. The capacity of a given population for agriculture is here just as much in question as the capacity of the soil, and I quite agree in principle with Sir William Crookes, that although additional soil might be available indefinitely for wheat in proper hands, yet as a matter of fact the soil practically available may be strictly limited. But what he fails to take sufficient note of, I believe, is the question of price. Land that would not be available for wheat with the price at 20*s.* to 25*s.* per quarter, might become available in indefinite quantities with the price at 40*s.* to 50*s.*, and even 60*s.*, which are by no means famine prices. But Sir William Crookes has little to say on this factor of price. Altogether, I may suggest, he relies too much on American statisticians, without having himself verified their methods. Mr. Davis for his purpose is not a quotable authority. He should have gone behind Mr. Davis and verified everything for himself.

The point on which the reference is made is rather a side one, but the danger of putting forth a sweeping statistical statement without adequate support is so well illustrated by it, that it may be useful to quote it. Sir William Crookes states, p. 35:

> "Taking the cost of producing a given quantity of wheat in the United Kingdom at 100*s.*, the cost for the same amount in the United States is 67*s.*, in India 66*s.*, and in Russia 54*s.*"

Surely it is altogether erroneous statistically to put forward a statement like this without references. How does Sir William Crookes know that England and the United States and the other countries mentioned differ so much as he states? The cost of production he refers to is either a maximum or a minimum, or a mean of two extremes, or an average; but which is it? As he makes the statement it is really unintelligible. If he means an average, as I presume must have been intended, how does he get the average? The statement is not one to be made in a scientific study without references and authorities, and full explanations of what is really meant.

In conclusion, I may express the hope that in some future essay Sir William Crookes will revise his present work, and not only look into his statistics, but inquire into the question of the play among different articles of food in agricultural production and in human consumption, instead of dealing with one article only. As to his suggested remedy for too little wheat, the fixing of the nitrogen of the atmosphere, it is one which may well be disconnected from the paper itself. Whatever may happen to wheat, the problem is one which should be attractive to the chemist on its own merits. It is, perhaps, unfortunate that the suggestion should have been appended to an alarmist statistical paper, instead of being made from the chemical side only, as the statistics seem to give little support to the suggestion.

R. Giffen.

THE PHYSICAL ATLAS.

Atlas of Meteorology. A series of over four hundred Maps prepared by J. G. Bartholomew, F.R.S.E., and A. J. Herbertson, Ph.D.; and edited by Alexander Buchan, LL.D., F.R.S. (Westminster: Archibald Constable and Co., 1899.)

Of the making of meteorological observations there is no end, and some, who have only a partial acquaintance with the subject, might be tempted to add, no result. But such a criticism, however smart, is eminently unjust, and as a protest against such an uncharitable opinion it was a wise and happy thought to endeavour to combine the outcome of the labours of many observers into a monumental form, which could appeal to the eye of many untrained in scientific methods, and convince them that time and thought and money had not been lavished in vain on mere childish records, but that earnest endeavour had harvested an abundance of facts, which only needed orderly arrangement and skilful grouping to make them available for instruction and edification. To the scientific mind well versed in such matters this compilation can appeal more strongly and more worthily, for it